JSO JOURNAL of STEM OUTREACH

Vol. 2, April 2019

Girls' STEM Identity Growth in Co-Educational and Single-Sex STEM Summer Camps

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Keywords: STEM Identity, Self-Efficacy, Informal STEM Education, Single-Sex

Publication Date: April 24, 2019

ABSTRACT: Informal STEM education programs have become venues wherein girls can improve their sense of belonging and potential success (STEM identity) through interactions with role models and seeing how STEM fields are relevant to them. Despite decades of advocacy for single-sex programs' role in improving girls' STEM identity, few studies have found definitive results. To explore the role that a single-sex environment can have on adolescent girls' STEM identity development, this study compares participating girls' STEM identity from pre- to post-test using linear regression and hierarchical linear modeling to determine whether participants have a larger identity growth in an all-girls informal STEM education summer camp (STEM GIRLS) or a co-educational informal STEM education summer camp (STEM STARS). Results indicate that STEM Self-Efficacy and STEM Identity are positively correlated, however, the model is currently incomplete and could use more clarity to determine the role one plays on the other. Despite this, our study indicates the value in addressing self-efficacy by giving girls opportunities to struggle through challenges. This study also found that both camps were similarly beneficial in impacting STEM Identity and STEM Self-Efficacy, further supporting research that highlights the gendered aspect of the camp is less impactful than the practices used.

INTRODUCTION

Girls and women have remained stubbornly underrepresented in many STEM fields, particularly physics, engineering, and computer science (National Science Foundation [NSF], 2016), despite attempts to increase girls and women's access to STEM programs and careers (American Association of University Women [AAUW], 2010; Spielhagen, 2008). One of the underlying assumptions for these access policies is that the culture of STEM does not need to change, but the women who enter should adjust to the masculine culture if they want to succeed (AAUW, 2010; Corbett and Hill, 2015). Other feminists argue that girls and women should be aware of cultural aspects of STEM that have historically affected (and continue to affect) women's persistence in STEM fields (Calabrese Barton, 1997; Lock and Hazari, 2016). Informal STEM education programs have become venues wherein this type of action and advocacy can occur in safe spaces where students can work with role models that look like them and work on projects that are relevant to them (Brotman and Moore, 2008; Calabrese Barton, et al., 2013). For girls, sometimes this safe space is an all-girl environment where they are free from the pressures of competing for males' attention or from the fear of speaking up because they see boys as being naturally gifted in STEM (Bracey, 2006; Dweck, 2006; Spielhagen, 2008). However, single-sex learning environments have come under attack by feminist groups and the American Civil Liberties Union (ACLU) as separate and not equal learning environments (AAUW, 2009; Gandy, 2006; Salomone, 2003).

Research studies on single-sex informal STEM education programs have shown mixed results because they measure various metrics that are not comparable or they only measure the effects of one program (Bhattacharyya et al. 2011; Farland-Smith 2012; Fields 2009; Jayaratne, et al., 2003; Kim, 2016; Munley and Rossiter, 2013). Studies that have included co-educational environments have shown mixed results as well (Barab and Hay, 2001; Hammack et al., 2015; Hughes et al., 2013). Research highlights that girls begin to question their sense of belonging and fit within STEM fields – which we refer to as STEM identity – during adolescence (AAUW, 2010; Archer et al., 2014; Tan et al., 2013; Unfried et al., 2014; Williams and Ceci, 2007). STEM identity – or a youth's sense of who they are and what they are capable of as it relates to STEM – influences who they want to be in the future. To explore the role that a single-sex environment can have on adolescent girls' STEM identity development, this study compares participating girls' STEM identity from pre- to post-test for youth who attended one of two informal STEM education programs over a four year period: an all-girls informal STEM education summer camp (STEM GIRLS) or a co-educational informal STEM education summer camp (STEM STARS). (Pseudonyms have been used for both camps.) The overarching research question guiding this study was: what impact does participation in a single-sex or co-ed STEM summer camp have on girls' STEM Identity[1] and STEM Self-Efficacy?

CONCEPTUAL FRAMEWORK

Research points to STEM identity as an important outcome and framework for studying the impacts of informal STEM education programs, particularly for girls (Munley and Rossiter, 2013). Yet there is little consensus across studies as to the definition of STEM identity. This study attempts to quantify changes in STEM identity for girls in one of two STEM summer camps over a four-year period by unifying existing related metrics. Both camps align with the National Research Council's (NRC) recommendations for assessing and developing successful informal science programs (2009). (A full description of the activities in both camps and how they align with the NRC can be found in Appendix A.) Although only the sixth practice mentions identity, all of these relate to STEM identity as evidenced by research. These six practices include: interest (Eccles, 2007; Hazari et al., 2010; Munley and Rossiter, 2013); the understanding of science knowledge (Munley and Rossiter, 2013; Tan et al. 2013); scientific reasoning as a form of competence (Carlone and Johnson, 2007); reflection (Lederman et al., 2002); engagement in scientific practices (Calabrese Barton and Brickhouse, 2006; Eccles, 2007); and developing identity as a science learner (Calabrese Barton and Brickhouse, 2006; Calabrese Barton et al., 2013).

To strengthen our understanding of STEM identity, we utilized Calabrese Barton and her colleagues' science identity framework (2013). The authors focused on identity work wherein individuals have opportunities to be supported and recognized in STEM spaces and these individuals must leverage these opportunities and the resources within to create positive STEM artifacts and conceptions. As individuals encounter new communities of practice (social and cultural), they use lessons learned in previous experiences to create new hybrid practices that can position them within the community of practice (Lave and Wenger, 1991) as a central or peripheral member. It is our contention that the two STEM summer camps that are the focus of our study represent students' first and/or peripheral exposure to the community of practice of STEM. In addition, the social interactions within the camps and the resulting camp events can have an effect on participants' STEM identity growth.

One of the key pieces of this framework is that there is always tension between an individual's identity work and how it is accepted or rejected by others. The NRC practices, along with Calabrese Barton and her colleagues' framing of identity influenced our choices of metrics. Specifically, we used metrics that allowed us to gather data on each participant's STEM interest – NRC practice 1 (Eccles, 2007; Munley and Rossiter, 2013; NRC, 2009); competence which includes NRC practices 2, 3, and 4 (Eccles, 2007; Munley and Rossiter, 2013; NRC, 2009), and sense of belonging as measured through perceptions of STEM and STEM professionals, which includes NRC practices 5 and 6 (Aschbacher et al., 2009; Munley and Rossiter, 2013; NRC, 2009). Calabrese Barton and her colleagues' research (2013) highlights the important role that recognition of others had on an individuals' sense of STEM. The connections between our conceptual framework, the NRC framework and the respective camp activities are detailed in Appendix A.

METHODS

The two camps that were the focus for this study are the single-sex STEM GIRLS camp and the co-educational STEM STARS camp. Both informal STEM education programs are housed within a national laboratory that is affiliated with a large research university. The goal of both programs is to increase participating youths' understanding of STEM career options by exposing them to potential STEM role models and relevant STEM activities and careers. The teachers are local middle school science teachers who have an understanding of STEM related issues impacting the participating campers. Each year the teachers participate in a training session before the camps which highlights required issues including: safety, first aid, effective practices for improving students' engagement in STEM (SciGirls Connect, 2012). The teachers in both camps work with local STEM professionals to plan activities that include hands-on activities and interactions with role models. Some overlapping activities are: building electromagnets and learning how they are related to Magnetic Resonance Imaging and meeting researchers in these fields; a trip to a nearby Marine Laboratory to conduct field sampling with researchers and learn more about human impact on the natural ecosystem; designing and testing the strength of pasta bridges with local engineers.

[1]When we reference our metrics for STEM Identity and STEM Self-Efficacy we use capital letters. Whenever we reference general STEM identity or self-efficacy as measured or mentioned in other studies we use lower case.

Participants in both camps were able to interact with scientists and engineers and participate in activities that these professionals planned. As a result, the students learned about, and were able to try on the identity of a scientist or engineer as well as interact with peers who shared similar levels of STEM interest in an environment that was structurally different from the formal classroom. We argue that the camp space serves as one of the three areas (home, school, and outside of school) wherein identity work can occur (Calabrese Barton et al., 2013). In fact, the camp's focus on crucial aspects of identity development give the youth opportunities to position themselves as scientists within a simplified community of practice by giving them extended time to work with STEM professionals. Teachers within the camps connect the camp activities to the other spaces of home and school. The camps also include a social component wherein the youth are surrounded by supportive peers. In addition, both camps provide time for youth to reflect on their activities through journaling or in-person group discussions. However, STEM STARS offers fewer female STEM role models. It was our hypothesis that STEM GIRLS would therefore have more of an impact on participating girls than STEM STARS.

Participants. Participants were rising 6th through 9th grade students who participated in one of the camps during the summers of 2013, 2014, 2015, and 2016. Campers are local students who learn about the camp through the local public television station and posters sent to all science and math elementary and middle school teachers in the county. Interested applicants must complete an application asking them about their interest in being part of the camp, experiences with group work, and career interests. The campers must also have a teacher recommendation letter. The teachers and camp directors review the applications to select up to 24 campers. The goal is to include a diverse group of campers each year. Diversity includes varying schools, grades, and career interests. Students may participate in each camp up to two times, but priority is given to students who have applied before and not been accepted so that more students are exposed to the program. Over the period of 2013-2016, 145 STEM GIRLS campers and 147 STEM STARS campers participated in the program and completed the pre- and post-surveys. Demographics of participants are presented in Table 1. Boys were included in our analysis of STEM STARS to help illuminate any potential gender differences in our outcomes of interest.

Survey Scales and Subscales. All students in the two camps were given a pre- and post-survey that included the Aschbacher and colleagues (2009) instrument and the Assessing Women in Engineering (2008) instrument. These two instruments include Likert scale questions on STEM interest, self-confidence, self-efficacy, and attitudes towards STEM. Both of the instruments have been validated by the authors (Aschbacher et al.., 2009; Assessing Women in Engineering, 2008). Missing data were handled using a two-phase approach, described in Appendix B. In order to narrow the focus of the study, exploratory factor analysis was conducted to create scales to measure STEM Identity. Table 2 includes our scales and subscales based on the factor analysis. Covariates for analysis included self-reported race, gender, age, and enrollment in honors or advanced classes. All of these demographics were self-reported on the survey and have been found to intersect with STEM identity and self-efficacy development (Eccles, 2007; Hazari et al., 2010; Rittmayer and Beier, 2009). (More details on our analysis and missing data procedures can be found in Appendix B).

Table 1. *Participant Demographics*

		Percent	
Age		**STEM GIRLS**	**STEM STARS**
	10	1.4%	9.0%
	11	23.2%	44.1%
	12	28.2%	23.4%
	13	30.9%	17.9%
	14	14.7%	4.8%
	15	1.4%	0.7%
Race/Ethnicity			
	Asian	21.7%	26.5%
	Black or African American	20.3%	12.2%
	White or Caucasian	53.8%	57.8%
	Hispanic or Latino/a	7.0%	6.1%
Sex			
	Male	0.0%	61.2%
	Female	100.0%	38.8%
Other Demographics			
	Currently enrolled in honors or advanced classes	81.1%	27.4%
Participants		145	147

RESULTS

Our results are divided into two parts based on the phases of analysis. In our phase 1 analysis we used linear regression to test our hypotheses related to the positive correlation of STEM Self-Efficacy to STEM Identity and whether girls with different demographics would have different levels of STEM Self-Efficacy and STEM Identity. Linear regression gives the pre- and post-results at individual points in time. Therefore to test our hypotheses related to growth in STEM Identity and Self-Efficacy we conducted hierarchical linear modeling (HLM).

Phase 1 Results. *Change in STEM Self-Efficacy and STEM Identity*. Paired sample t-tests comparing STEM Identity

Table 2. *Survey Questions and Corresponding Scales*

Scale	Subscale	Items
STEM Identity	Self-Perception (α = .873)	Science is something I rarely even think about. (Reverse Coded)
		I would feel a loss if I were forced to give up doing science.
		I really don't have any clear feelings about science. (Reverse Coded)
		Science is an important part of who I am.
		Being a scientist is an important part of my identity.
		No one would really be surprised if I just stopped doing science. (Reverse Coded)
	External Perception (α = .881)	I am likely to choose a career in science.
		I spend much of my time doing science related activities.
		Many people think of me in terms of being a scientist.
		Other people think doing science is important to me.
		It is important to my friends and relatives that I continue as a scientist.
		Many of the people that I know expect me to continue as a scientist.
STEM Self-Efficacy	Self Confidence (α = .840)	I can understand difficult ideas in school.
		I can explain science to my friends to help them understand.
		I know where I can find the information that I need to solve difficult problems
		I can effectively lead a team to design and build a hands-on project.
		In lab activities, I can use what I have learned to design a solution.
		I can teach myself to use new technologies.
		I can use what I know to design and build something mechanical that works.
	Openness to Challenge (α = .814)	I look forward to math class in school.
		I am capable of getting straight A's.
		I like classes that are easy for me more than classes that challenge me. (Reverse Coded)
		When an assignment turns out to be harder than I expected, I usually don't complete it. (Reverse Coded)
		I can get good grades in math.
		I can explain math to my friends to help them understand.
		When I see a new math problem, I can use what I have learned to solve the problem.
	Willingness to Learn (α = .791)	I look forward to science classes in school.
		I like learning how things work.
		I can learn new ideas quickly in school.
		I am good at learning new things in school.
		School is easy for me.
		I can get good grades in science.

and STEM Self-Efficacy from pre- to post-camp showed no statistically significant differences in these two scales for the STEM GIRLS camp, but we found significant differences in both scales for the STEM STARS (co-ed) camp (STEM Identity $d= 0.18$, $p=.037$, STEM Self-Efficacy, $d=0.18$, $p=.035$). In order to better understand these findings, and to see how demographic characteristics impacted pre- and post-camp levels of STEM Self-Efficacy and STEM-Identity, we conducted linear regressions on each of the scales. We included gender, race, age, and enrollment in honors or advanced classes as covariates.

Impacts of Student Demographic Characteristics on STEM Self-Efficacy and STEM Identity. Overall, only a few demographic characteristics significantly predicted pre- and post-camp STEM Self-Efficacy (Table 2) and STEM Identity (Tables 3 and 4). Race, ethnicity, and gender had no strong influence on the STEM Self-Efficacy and STEM Identity scales in our data, which is counter to our hypothesis. This indicates that students of different genders, races, and ethnicities enter without significant differences in their STEM Self-Efficacy. However, we found that for both camps, age (Single-sex $\beta=-.114$, $p=.001$; co-ed $\beta=-.088$, $p=.007$) and enrollment in honors or advanced classes (Single-sex $\beta=-.234$, $p=.020$; co-ed $\beta=-.206$, $p=.009$) were negative predictors of overall STEM Self-Efficacy pre-camp, meaning that those students who had participated in more formal schooling and

Table 3. *Linear Regression Analysis for Pre-Camp STEM Self-Efficacy*

	Single-sex Camp *Beta (Standard Error)*	Co-ed Camp *Beta (Standard Error)*
Black or African American	-0.015 (0.177)	0.031 (0.157)
Hispanic or Latino/a	0.074 (0.180)	-0.062 (0.155)
White or Caucasian	-0.110 (0.163)	-0.027
Asian	0.075 (0.171)	0.075 (0.171)
Age	-0.114*** (0.036)	-0.088*** (0.33)
Are you currently enrolled in honors or advanced class?	-0.234** (.101)	-0.206*** (0.079)
Sex	- (-)	-0.087 (0.072)
Observations	145	147
R-squared	0.127	0.148

**** p<0.01, ** p<0.05, * p<0.1*

Table 4. *Linear Regression Results for Post-Camp STEM Identity with Pre-Camp STEM Self-Efficacy as a Covariate*

	Single-sex Camp *Beta (Standard Error)*	Co-ed Camp *Beta (Standard Error)*
Black or African American	-0.117 (0.275)	-0.331 (0.249)
Hispanic or Latino/a	-0.090 (0.285)	0.032 (0.248)
White or Caucasian	-0.109 (0.255)	0.076 (0.197)
Asian	-0.022 (0.266)	0.270 (0.204)
Age	0.027 (0.057)	0.004 (0.053)
Are you currently enrolled in honors or advanced class?	-0.011 (0.160)	0.250 (0.128)
Sex	- (-)	-0.055 (0.115)
STEM Self-Efficacy (Pre)	0.517*** (0.132)	0.912*** (0.136)
Observations	145	147
R-squared	0.121	0.337

**** p<0.01, ** p<0.05, * p<0.1*

Table 5. *Linear Regression Results for Post-Camp STEM Identity with Post-Camp STEM Self-Efficacy as a Covariate*

	Single-sex Camp *Beta (Standard Error)*	Co-ed Camp *Beta (Standard Error)*
Black or African American	-0.097 (0.255)	-0.233 (0.241)
Hispanic or Latino/a	-0.061 (.265)	0.068 (0.235)
White or Caucasian	-0.062 (.237)	0.150 (0.192)
Asian	0.005 (0.246)	0.285 (0.199)
Age	0.078 (0.053)	0.003 (0.050)
Are you currently enrolled in honors or advanced class?	0.096 (.149)	0.233 (0.050)
Sex	- (-)	-0.039 (.109)
STEM Self-Efficacy (Post)	0.816*** (0.128)	0.988*** (0.120)
Observations	145	147
R-squared	0.247	0.42

**** p<0.01, ** p<0.05, * p<0.1*

were theoretically excelling (by enrolling in honors or advanced classes) had lower STEM Self-Efficacy when they entered the camp (see Table 3).

For the next part of the phase one analysis, we conducted linear regression analysis on the STEM Identity scale. We utilized the same demographic characteristics that we included for STEM Self-Efficacy linear regression analysis and added in STEM Self-Efficacy as a covariate to see what relationship existed in our data between our two key metrics. We ran two sets of analyses, one with pre-camp STEM Self-Efficacy (Table 3), and one with post-camp STEM Self-Efficacy (Table 4). For both sets of analysis, demographic characteristics held no statistical significance for post-camp STEM Identity. It is important to note that gender was not a significant predictor for the co-ed STEM STARS camp, indicating that girls in the STEM STARS camp had similar post-camp STEM Identity as the boys.

The only significant predictor in both models was STEM Self-Efficacy. When we compared the impacts of STEM Self-Efficacy in each camp, we saw that the beta for the single-sex camp was lower than the beta for the co-ed camp in the pre-camp model (Table 4), but the betas were close to the same value in the post-camp model (Table 5). From these results we can see that STEM Self-Efficacy plays a central role in STEM Identity, and plays a bigger role than race or ethnicity. However, the exact role that STEM Self-Efficacy plays remains unclear. The discrepancy in betas from the linear regression is difficult to contextualize, so to help clarify this finding, we conducted HLM analysis in phase two to help us model individual growth across the camp.

Phase 2 Results. For the next phase of analysis, we used hierarchical linear modeling (HLM) to examine growth in STEM Self-Efficacy and STEM Identity. Pre- and post-camp scale scores were treated as level one and individual characteristics were treated as level two so that our analyses modeled time points nested within individuals. We ran a separate model for each camp for both STEM Self-Efficacy and STEM Identity. This analysis provided insight into trends across individual trajectories of STEM Self-Efficacy and STEM Identity, and allowed us to examine participants' growth in STEM Identity and STEM Self-Efficacy during their participation in either STEM STARS or STEM GIRLS. The HLM analysis was conducted in three separate models: a null model, a model with linear growth from pre- to post-camp scores but without covariates, and then the full model which included linear growth, age, race, gender, and the interaction of age, race, and gender with growth.

HLM analyses yielded few statistically significant differences (see Tables 6 and 7). Our first phase of analyses established a strong connection between STEM Self-Efficacy and STEM Identity, and the HLM seems to support this concept by continuing to show correlation between STEM Identity

Table 6. *HLM Results for STEM Identity*

	Single-sex Camp *Beta (Standard Error)*	Co-ed Camp *Beta (Standard Error)*
Time (Pre to Post change)	-0.031 (0.640)	0.620 (0.646)
Black or African American	-0.168 (0.338)	-0.129 (0.316)
Hispanic or Latino/a	0.059 (0.363)	0.484 (0.304)
White or Caucasian	-0.135 (0.311)	0.347 (0.264)
Asian	-0.095 (0.323)	0.490* (0.272)
Age	0.008 (0.071)	-0.035 (0.069)
Sex	- (-)	-0.007 (0.146)
STEM Self-Efficacy	0.890*** (0.149)	0.994*** (0.091)
Time*Black or African American	0.027 (0.167)	-0.093 (0.166)
Time*Hispanic or Latino/a	-0.074 (0.184)	-0.247 (0.160)
Time*White or Caucasian	0.026 (0.156)	-0.107 (0.138)
Time*Asian	0.038 (0.160)	-0.127 (0.143)
Time*Age	0.029 (0.035)	0.003 (0.036)
Time*Sex	- (-)	-0.025 (0.078)
Time*STEM Self-Efficacy	-0.069 (0.083)	-0.102 (0.091)
Observations	145	147
ICC	0.78	0.322

**** p<0.01, ** p<0.05, * p<0.1*

Table 7. *HLM Results for STEM Self-Efficacy*

	Single-sex Camp *Beta (Standard Error)*	Co-ed Camp *Beta (Standard Error)*
Time (Pre to Post change)	.339 (.295)	.101 (.261)
Black or African American	.004 (.223)	.164 (.208)
Hispanic or Latino/a	.137 (.226)	-.053 (.205)
White or Caucasian	-.092 (.205)	.301 (.168)*
Asian	.135 (.215)	.172 (.173)
Age	-.093 (.044)**	-.088 (.043)
Sex	- (-)	-.079 (.095)
Enrolled in Honors or Advanced Classes	.189 (.128)	.237 (.105)**
Time*Black or African American	-.019 (.102)	-.119 (.099)
Time*Hispanic or Latino/a	-.063 (.104)	-.015 (.097)
Time*White or Caucasian	-.017 (.095)	-.080 (.080)
Time*Asian	-.060 (.009)	-.006 (.082)
Time*Age	-.020 (.021)	.002 (.020)
Time*Sex	-(-)	.006 (.045)
Time*Currently Enrolled in Honors or Advanced	-.045 (.060)	-.034 (.049)
Observations	145	147
ICC	0.823	0.753

**** p<0.01, ** p<0.05, * p<0.1*

and STEM Self-Efficacy (Table 6), but the HLM analysis did not show any significant growth overall in either of these metrics over the course of the camp. This would indicate that STEM Self-Efficacy and STEM Identity do go hand-in-hand, but a high score in one does not necessarily guarantee growth in the other. Student demographic characteristics also did not impact individual growth in our dataset. Our analyses indicated no patterns of student growth based on gender, race, ethnicity, age, or STEM Self-Efficacy scores. This could be due to the fact that students in these camps entered with relatively high scores in both STEM Self-Efficacy and STEM Identity, leaving only a little room for growth. However, the lack of negative results indicates that these high levels are being maintained over the course of the respective camps, and being equally maintained across demographic groups, which highlights the success of the camp.

The HLM analysis for STEM Identity supports the notion that STEM Self-Efficacy plays a key role in STEM Identity. To explore this role we conducted an HLM analysis with STEM Self-Efficacy as the outcome variable and keeping race, ethnicity, age, sex, and enrollment in honors or advanced classes as covariates (Table 7). Overall we found no significant changes from pre- to post-camp, indicating no consistent growth in STEM Self-Efficacy across students over the course of the camp.

DISCUSSION

Our analyses showed that STEM Self-Efficacy (defined here as a combination of the subscales: Self-Confidence, Openness to Challenge, and Willingness to Learn) is crucial in the process of maintaining STEM Identity for participants in the camps, thereby demonstrating that these two concepts are strongly correlated for our participants. Our data did not indicate any statistically significant impacts of race and/or ethnicity on either STEM Identity or STEM Self-Efficacy for participants in the camps. This is surprising since previous studies have found that demographics, particularly marginalized identities, were negatively linked to positive STEM identity development (Brotman and Moore, 2008; Calabrese Barton et al., 2013; Jayaratne et al., 2003).

Our data did indicate that girls' age and enrollment in honors or advanced classes negatively impacted their pre-camp levels of STEM Self-Efficacy in both camps. This finding was the same for boys and girls as well, in that the older a student was, the lower their STEM Self-Efficacy score was likely to be. In addition, students who were enrolled in honors or advanced classes were more likely to have a lower pre-camp STEM Self-Efficacy score. One possible explanation for these findings is that older students and students enrolled in honors or advanced classes are less open to challenge or have encountered challenges within their formal school STEM classes that have led them to be less confident about their abilities in STEM. Our STEM Self-Efficacy metric includes an Openness to Challenge subscale, and research has shown that students can be acutely aware of the "good student stereotype" that does not leave room for students to make mistakes and to learn from their mistakes, which can make students averse to challenging situations and subjects (Carlone, 2003; Dweck, 2006; Tan et al., 2013).

Calabrese Barton and her colleagues (2013) have demonstrated the importance of understanding STEM identity work, particularly for girls of color. We had hoped that our HLM analysis would allow us to quantitatively measure identity growth and compare it across a co-educational and a single-sex program. However, our models had a notable amount of unexplained variance, indicating that there are other metrics that we need to measure. Our results indicate that neither camp had a stronger impact on girls', including girls of color, STEM Identity scores. Our preliminary analyses indicated that age and enrollment in honors courses were negatively correlated with STEM Self Efficacy, two populations that are oversampled in our single-sex camp compared to the co-ed camp. As a result of this oversampling, we had anticipated more room for growth in STEM Self Efficacy for this group, but we did not see significant growth in this group, and HLM analyses showed these two characteristics did not correlate to either positive or negative changes in STEM Self-Efficacy over the course of the program. The one factor that remained consistent in our analyses was the interplay of STEM Self Efficacy and STEM Identity, however we were not able to parse out which component more strongly affects the other.

The STEM GIRLS camp had more changes in STEM-Identity within individuals than across individuals (ICC=.780, see Table 6), whereas the STEM STARS campers had more changes between individuals (ICC=.322, see Table 6) but these were not statistically significant. The type of person attracted to the camp might be the reason for this. Perhaps, girls seeking an all-girls environment have a higher potential for individually improving their STEM identity. One potential metric to explain variance could be the concept of STEM capital (Archer et al., 2015), which strives to measure how much social capital specifically related to STEM fields students' possess. This metric could explain more of the variance in STEM Self-Efficacy and STEM Identity and should be tested in future studies.

CONCLUSIONS AND FUTURE PROSPECTS

As we have stated, our goal for this study was to determine the impact of an all-girls camp compared to a co-educational camp on girls' STEM identity growth. Although our current model does not fully capture this, the study is an important early step towards this development. It has also provided us with important findings for practitioners and researchers. For practitioners, our study indicates that the camp activities may need to focus more on developing STEM Self-Efficacy since this concept was so closely linked to STEM Identity. Research has indicated that telling girls about the issues they may face in future STEM careers (Lock and Hazari, 2016) and/or developing a growth mindset in students (Dweck, 2006) could potentially increase their STEM Identity. Practitioners, particularly teachers leading informal STEM education program, may want to add these explicit components of STEM Self-Efficacy development into their programs to determine what effect that has on STEM Identity. For research on STEM Identity growth, camp experiences may be too short to engender STEM Identity development. Future studies should add a third time point a year after participation to determine if changes exist over a longer time period.

The most surprising finding from this study was the relatively similar outcomes for girls in both camps. We had expected girls to experience greater gains in STEM Identity in a single-sex environment where girls can operate free of gender stereotypes and build a community with other girls with whom they share interest. While we did not see significant growth in either camp, girls' STEM Self-Efficacy and STEM Identity were maintained over the course of the camp, and were maintained equally across demographic groups. This indicates that the structure of both camps – based on the NRC framework – was beneficial for participants whereas the all-girls environment did not appear to be necessary for STEM identity growth. This is an important finding in that it highlights that informal STEM education programs need not focus on the gendered structure, rather these programs should focus on developing stronger STEM self-efficacy within participants. This improvement in STEM self-efficacy is more impactful on students' STEM identity than the gendered structure of the camp. This finding is especially crucial considering that middle school is a pivotal point in the STEM pipeline, especially for girls and girls of marginalized identities. This study informs future research that attempts to develop identity metrics to improve research in the impacts of informal STEM education programs.

ASSOCIATED CONTENT

Referenced appendices can be found uploaded along with this manuscript.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

FUNDING SOURCES

This study was supported by the National Science Foundation, Cooperative Agreement No. DMR-1644779 and the State of Florida.

ABBREVIATIONS

HLM: Hierarchical Linear Modeling; STEM: Science, Technology, Engineering, Math.

REFERENCES

American Association of University Women (AAUW). (2009). Separated by sex: Title IX and Single-sex education (Position paper). Washington, DC: AAUW Public Policy and Government Relations Department.

American Association of University Women (AAUW). (2010). Why so few? Women in science, technology, engineering, and mathematics (Report). Washington, DC: Author.

Archer, L., Dawson, E., DeWitt, J., Seakins, A., and Wong, B. (2015). "Science Capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts. Journal of Research in Science Teaching, 52, 922-948.

Archer, L., DeWitt, J., and Dillon, J. (2014). 'It didn't really change my opinion': exploring what works, what doesn't and why in a school science, technology, engineering and mathematics careers intervention. Research in Science and Technological Education, 32(1), 35-55.

Aschbacher, P. R., Li, E., and Roth, E. J. (2009). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. Journal of Research in Science Teaching, 47, 564-582.

Assessing Women in Engineering (AWE), 2008. Assessing Women and Men in Engineering website. Retrieved from http://www.engr.psu.edu/awe/secured/director/precollege/pre_college.aspx accessed 25 March 2009

Barab, S.A., and Hay, K.E. (2001). Doing science at the elbows of experts: Issues related to the science apprenticeship camp. Journal of Research in Science Teaching, 38, 70-102.

Bhattacharyya, S., Nathaniel, R., and Mead, T.P. (2011). The influence of science summer camp on African-American high school students' career choices, School Science and Mathematics, 111, 345-353.

Bracey, G.W. (2006). Separate but superior? A review of issues and data bearing on single-sex education. Tempe: Educational Policy Research Unity (EPRU), EPSL-0611-221-EPRU.

Brotman, J.S., and Moore, F.M. (2008). Girls and science: A review of four themes in the science education literature. Journal of Research in Science Teaching, 45, 971-1002.

Calabrese Barton, A. (1997). Liberatory science education: Weaving connections between Feminist theory and science education. Curriculum Inquiry, 27, 141-163.

Calabrese Barton, A., and Brickhouse, N.W. (2006). Engaging girls in science. In C. Skelton, B. Francis and L. Smulyan (Eds.), Handbook of gender and education (pp. 221-235). Thousand Oaks, CA: Sage.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T.B., Bautista-Guerra, J., and Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. American Educational Research Journal, 50, 37-75.

Carlone, H. B. (2003). The cultural production of science in reform-based physics: Girls' access, participation and resistance. Journal of Research in Science Teaching, 41, 392-414.

Carlone, H.B., and Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens, Journal of Research in Science Teaching, 44, 1187-1218.

Corbett, C., and Hill, C.H. (2015). Solving the Equation: The Variables for Women's Success in Engineering and Computing, American Association of University Women, Washington, DC: AAUW.

Dweck, C. (2006). Mindset: The new psychology of success, New York: Ballantine Press.

Eccles, J. S. (2007). Where are all the women? Gender differences in participation in physical science and engineering. In S. J. Ceci and W. M. Williams (Eds.), Why aren't more women in science? Top researchers debate the evidence (pp. 199-210). Washington, DC: American Psychological Association.

Farland-Smith, D. (2012). Personal and social interactions between young girls and scientists: Examining critical aspects for identity construction, Journal of Science Teacher Education, 23, 1–18.

Fields, D.A. (2009). What do students gain from a week at science camp? Youth perceptions and the design of an immersive, research-oriented astronomy camp, International Journal of Science Education, 31, 151–171.

Gandy, K. (2006, March 28). Separation threatens girls. USA Today. Retrieved from http://www.now.org/issues/education/060328op-ed.html on 28 March, 2006.

Hammack, R., Ivey, T.A., Utley, J., and High, K.A. (2015). Effect of an engineering camp on students' perceptions of engineering and technology, Journal of Pre-College Engineering Education Research (J-PEER), 5, 10-21.

Hazari, Z., Sonnert, G, Sadler, P.M., and Shanahan, M.C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. Journal of Research in Science Teaching, 47, 978-1003.

Hughes, R., Nzekwe, B., and Molyneaux, K. (2013).The single sex debate for girls in science: A comparison between two informal science programs on middle school students' STEM identity formation. Research in Science Education Journal. 43(5), 1979-2007.

Jayaratne, T.E., Thomas, N.G., and Trautmann, M. (2003). Intervention program to keep girls in the science pipeline: Outcome differences by ethnic status. Journal of Research in Science Teaching, 40, 393-414.

Kim, H. (2016). Inquiry-Based science and technology enrichment program for middle school-aged female students, Journal of Science Education and Technology, 25, 174-186.

Lave, J., and Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. New York: Cambridge University Press.

Lederman, N.G., Abd-El-Khalick, Bell, R.L., and Schwartz, R.S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science, Journal of Research in Science Teaching, 39, 497-521.

Lock, R. M., and Hazari, Z. (2016). Discussing underrepresentation as a means to facilitating female students' physics identity development. Physical Review Physics Education Research, 12, 1-14.

Munley, M.E., and Rossiter, C. (2013). Girls, equity and STEM in informal learning settings. A review of literature: Girls RISEnet/SAVI Planning group. Retrieved on April 1, 2017 from http://www.informalscience.org/girls-equity-and-stem-informal-learning-settings-review-literature

National Research Council (NRC). (2009). Learning Science in Informal Environments: People, Places, and Pursuits, Washington, DC: The National Academies Press.

National Science Foundation (NSF). (2016). Women, minorities, and persons with disabilities in science and engineering National Center for Science and Engineering Statistics, special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2014. Table 5-7. Bachelor's degrees awarded, by citizenship, ethnicity, race, sex, and field: 2014. Retrieved from https://www.nsf.gov/statistics/2017/nsf17310/data.cfm

Rittmayer, M.A., and Beier, M.E. (2009). Self-Efficacy in STEM. In B. Bogue and E. Cady (Eds.). Applying Research to Practice (ARP) Resources. Retrieved from http://www.engr.psu.edu/AWE/ARPresources.aspx. Accessed on 5 January 2010.

Salomone, R.C. (2003). Same, different, equal: Rethinking single-sex schooling. New Haven, CT: Yale University Press.

SciGirls Connect (2012). Scigirls Seven Strategies, Retrieved on January 18, 2012 from www.scigirlsconnect.org. The original was updated in 2016: http://www.scigirlsconnect.org/wp-content/uploads/2016/07/ScigirlsSeven_Print.pdf

Spielhagen, F. R. (2008). Having it our way: Students speak out on single-sex classes. In F. R.

Spielhagen (Ed.), Debating single-sex education: Separate and equal (pp. 32-46). Baltimore, MD: Rowan and Littlefield.

Tan, E., Calabrese Barton, A., Kang, H., and O'Neile, T. (2013) Desiring a career in STEM-related fields: How middle school girls authenticate and negotiate identities-in-practice in science, Journal of Research in Science Teaching, 50, 1143-1179.

Unfried, A., Faber, M., and Wiebe, E. (2014). Gender and student attitudes toward science, technology, engineering, and mathematics. The Friday Institute for Educational Innovation at North Carolina State University. Retrieved from https://www.researchgate.net/profile/Malinda_Faber/publication/261387698_Gender_and_Student_Attitudes_toward_Science_Technology_Engineering_and_Mathematics/links/0c96053428b542ca8c000000.pdf

Williams, W.M., and Ceci, S.J., (2007). Introduction: Striving for perspective in the debate on women in science, in S.J. Ceci, and W.M. Williams, eds., Why aren't more women in science? Top researchers debate the evidence, American Psychological Association, Washington DC, pp. 3–23, 2007.

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